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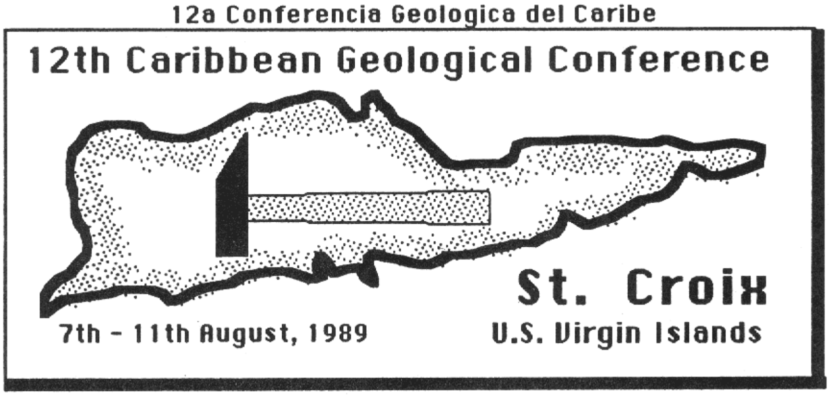

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THE CHORTIS BLOCK IS A CONTINENTAL, PRE-MESOZOIC TERRANE

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ABSTRACT

The Chortís block consists of well-dated Mesozoic and Cenozoic formations which unconformably overlie basement of metamorphic rocks which have not been well-dated. The basement rocks are dominantly low grade metasedimentary rocks. One metamorphosed intrusion within the metasedimentary rocks has been dated as Paleozoic in age. The crustal thickness determined from seismic studies demonstrates that the Chortís block has crust with a thickness and seismic velocity typical of continental-type crust. The basement is overlain by sedimentary formations which were deposited under terrigenous or shallow marine conditions. The environment of deposition of these formations suggest that the Chortís block did not experience significant deformation during the Early Cretaceous. Deposition of redbeds occurred during the Late Cretaceous, while volcanic activity was limited in extent. Late Cretaceous limestones were also deposited under shallow marine conditions. Thus, available data clearly demonstrate that the Chortís block has continental-type crust which is pre-Mesozoic in age. During the Mesozoic, the Chortís block experienced platform-type sedimentation. Within the central portion of the block, extensive volcanism occurred only during the Cenozoic.

INTRODUCTION

The Chortís block is the best example of an allochthonous terrane in the Caribbean region, and nearly all workers agree with this interpretation (Dengo, 1969; Case et al., 1984; Gose, 1985; Donnelly, 1989). Because it is an important element of the Caribbean tectonic puzzle, the fundamentals about the geology of the Chortís block need to be widely understood among Caribbean geologists. First of all, we must understand the distinctive basement geology of the block (Dengo, 1969; Table 1). Furthermore, the well-known Mesozoic stratigraphy should be considered when the Mesozoic tectonics of the Chortís block are discussed.

The Chortís Block was defined by Dengo (1969) as the area of northern Central America which is south of the Motagua fault zone (Fig. 1). Although Dengo (1969) did not set a southern limit to the Chortís block, Dengo and Bohnenberger (1969) placed the boundary between northern and southern Central America at latitude 12° 30' N. They used a latitude because a suitable geologic feature had not been recognized as the boundary between two distinct crustal types. Dengo did not attempt to continue the boundaries offshore. Case et al. (1984) suggest that the Chortís block is a superterrane, and discuss the geology of the offshore regions. To the southwest, the Chortís block terminates against the southern Central America province. Case et al. (1984) cite evidence that this oceanic crustal terrane (see Weyl, 1980) extends from Costa Rica offshore to the northwest between the Middle America trench and the Pacific coastline. Based on crustal type (Case et al., 1984), the Chortís block almost certainly continues offshore on the Caribbean side. Basement rocks crop out in the Bay Islands (McBirney and Bass, 1969; Fig. 1) indicating a Chortís-type crust for this region. Part of the Nicaraguan Rise is probably Chortís-type crust. Jamaica is geologically distinct from the Chortís block and has a gravity signature suggestive of oceanic crust (Case et al., 1984). Thus, a boundary between different crustal types occurs within the Nicaraguan Rise. Greater Chortís may be an appropriate name for the part of the northwestern Caribbean which has been rotating past Yucatán since the Eocene. However, Jamaica was probably independent of Chortís during the Mesozoic.

CACAGUAPA SCHIST

The Cacaguapa Schist was named by Fakundiny (1970) after a village surrounded by good outcrop of schist north of Comayagua, Honduras (Fig. 1). Basement rocks of the Chortís block had previously been mapped by Carpenter (1954) and Zoppis Bracci (1961) who used different names. Mapping since 1970 has confirmed that these metamorphic rocks are widespread and are the same rock unit. The dominant rock types are phyllitic and graphitic schists.

Fakundiny (1970) identified two members within the schist: the Humuya Member and the Las Marías Member. The Humuya Member has only been reported from the gorge of Río Humuya (north of Comayagua, Fig. 1). It consists of greenish gray to black schist with intercalated igneous flows. These rocks are interlayered with metaconglomerate and epidote-rich quartzite which suggest a metasedimentary origin for the Humuya Member.

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CHARACTERISTICS OF BASEMENT ROCKS, CENTRAL AMERICA

Terrane (as defined by Dengo)	Chortís block	Maya block	Southern Central America
Rock type	low grade phyllites Cacaguapa Schist Greenschist metamorphic rocks Some higher grade rocks exposed Some metaigneous rocks exposed (e.g., Simonson 1977)	amphibolitic schist Chuacús Metamorphics garnet amphibolites (McBirney, 1963)	oceanic/ophiolitic Santa Elena complex (Weyl, 1980)
Crustal thickness/ Seismic velocities (km/sec)	37 km 2.6/5.1/6.2/6.6/7.9 (Kim et al., 1982)	43 km 5.0/6.1/6.95/7.6/8.2 (Castro Escamilla, 1980)	43 km 5.1/6.2/6.6/7.9 (Matumoto et al., 1977)
Crustal type	continental	continental	Transitional Ocean/island arc
Age	pre-Mesozoic presumed Paleozoic (see text)	Paleozoic metamorphism 1100 Ma protolith? (Gomberg et al., 1968)	Mesozoic (Weyl, 1980)

Table 1. The terranes of Central America were defined by Dengo (1969) and Dengo and Bohnenberger (1969). The basement rocks of each terrane are distinct. The crustal thicknesses velocities are similar for the three terranes. Matumoto et al. (1977) noted that the geology of southern Central America is oceanic. However, their velocity model indicates that the origin of southern Central America is similar to other circum-Pacific island arcs. Kim et al. (1982) believe that further study is needed to explain the discrepancy between geological data and seismic data for southern Central America.

The Las Marías Member has been found in numerous localities on the Chortís block since the time of Fakundiny, and is similar to the metamorphic rocks described by Carpenter (1954). Greenschist metasedimentary rocks are the most common rock type, although some amphibolite grade rocks may be present (Fakundiny, 1970). The bulk of the unit is chlorite, white mica, and quartz phyllite. Interlayered with the phyllites are marbles (Fakundiny, 1970; Simonson, 1977; Rodbell, 1986; Kozuch, 1989), quartzites (Fakundiny, 1970; Simonson, 1977), and metaconglomerates (Fakundiny, 1970). These rock types demonstrate that the Las Marías member is dominantly metasedimentary. Simonson (1977) mapped metamorphosed mafic igneous rocks and metamorphosed epiclastic rocks which are interlayered with the phyllite. These metavolcanic rocks are volumetrically minor.

Although the phyllite unit is the most common exposed basement rock on the Chortís block, Horne et al. (1976) and Simonson (1977, 1981) have demonstrated that more rock types are present. Horne et al. (1976) found higher grade rocks than had been found in central Honduras. In the Sierra de Omoa (Fig. 1), they recognized almandine amphibolite facies. Hornblende, calcic plagioclase and epidote are widespread in this area whereas garnet and staurolite are only found locally. The rock sequences that they report are mostly metasedimentary because they are interbedded with garnetiferous gneiss, staurolite schist and marble. Low grade phyllite like the Las Marías Member and metaigneous rocks are also exposed in this region.

In the El Porvenir region (Fig. 1), Simonson (1977, 1981) described and mapped five separate members of the Cacaguapa Schist of which three are metasedimentary and two are metaigneous. Some of the metasedimentary rocks are higher grade than had been previously documented in Central Honduras. He called this unit the Garnet Schist Member although it includes several rock types and a variety of minerals. The principal schist member consists of garnet, chlorite, biotite, highly sodic plagioclase and chloritoid. A mafic schist is present. The highest metamorphic grade was epidote-amphibolite facies. Simonson also found quartzite and marble. Quartzite layers tens of meters thick occur throughout the schist, but are not thick enough to be mapped separately. The pelitic nature of most of the member, the presence of the marble member and the common occurrence of quartzite all attest to the metasedimentary nature of this member. The phyllite member mapped by Fakundiny crops out extensively in the El Porvenir quadrangle. Quartzite, marble and mafic schist occur in the phyllite

MAPPED BASEMENT OF THE CHORTIS BLOCK

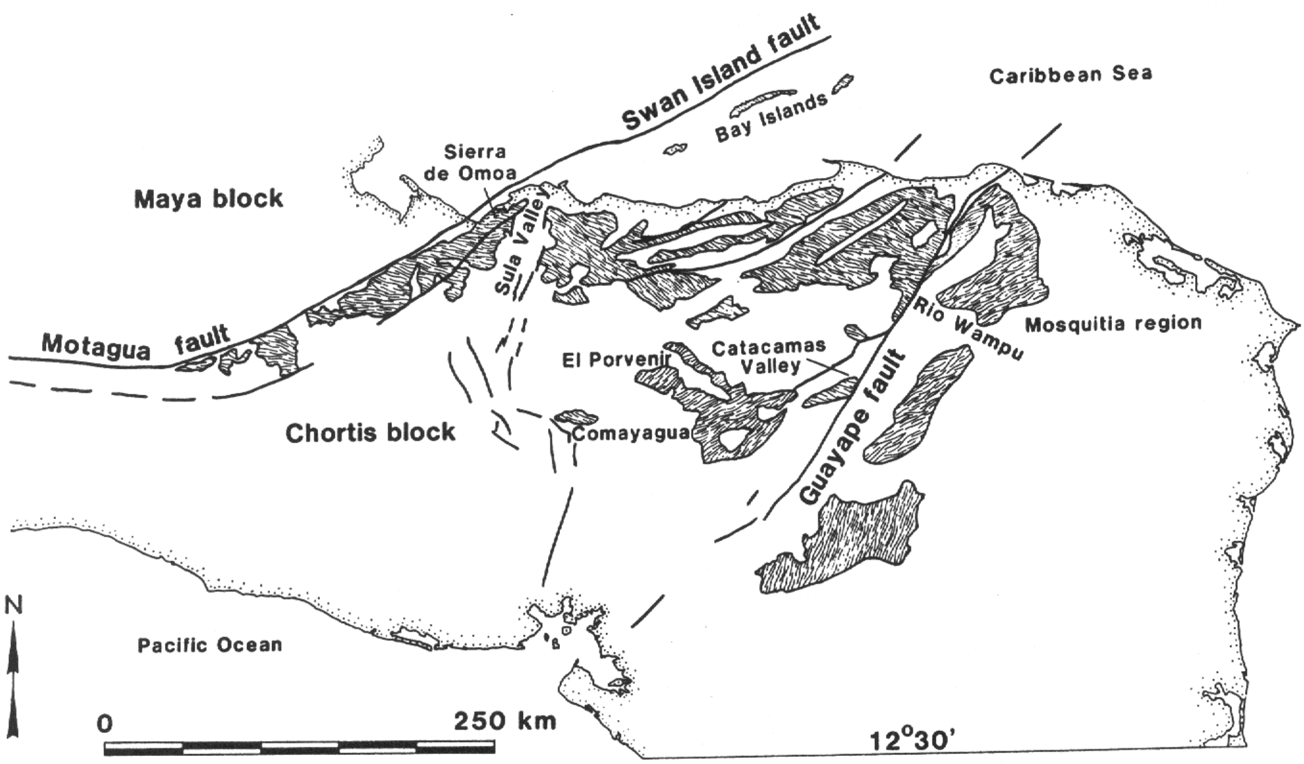

Figure 1. Mapped basement of the Chortís block. Foliations within mapped regions commonly have complex orientations, and pattern is not intended to indicate general strike. Basement rocks have been found under relatively undeformed Mesozoic sedimentary rocks throughout the Chortís block. Much of Honduras has been stripped to the basement, and large regions of nearly exclusive basement exposures exist. Nearly all of Honduras has a basement of metamorphic rocks. Map is modified from Case and Holcombe (1980) based on recent mapping and my reconnaissance studies.

member as well. The member is gray and golden tan, and its mineralogy consists of sericite, chlorite and quartz. Based on their general similarity in bulk composition, Simonson (1977) considered the garnet schist member and the phyllite member as one unit with different metamorphic grades.

Metaigneous rocks have been found in northern Honduras by Horne et al. (1976) and in central Honduras by Simonson (1977). Fakundiny (1971) mapped a mylonitized granite, but did not describe it in detail. A metapluton is exposed on the west side of the Sula Valley at Quebrada Seca (Horne et al., 1976). Phases of the pluton include metatonalite, porphyritic metadacite, metadiorite, and quartz-monzonite gneiss. Horne et al. also described a metapluton from Banaderos, within the Sierra de Omoa. This metapluton includes granodiorite gneiss and tonalite granofels. Simonson (1977, 1981) mapped two distinct types of metaintrusions. Two of these are relatively low-grade mylonite gneisses. The rocks have undergone strain and recrystallization without extensive change in their original mineralogy or texture. If no chemical change occurred during metamorphism, one pluton is metatonalite and the other is metagranite. Simonson's mapping shows that these plutons intruded the metasedimentary rocks prior to metamorphism. Simonson (1977, 1981) also mapped a more highly deformed metaplutonic rock which he called the augen schist member. This member has abundant augens of microcline and recrystallized quartz with white mica and biotite anastomosing around feldspathic augen. Epidote is also present. Simonson (1977) proposes that the augen schist predates the garnet schist. Thus, the augen schist is the oldest metamorphic unit and the metasedimentary rocks were deposited on the augen schist.

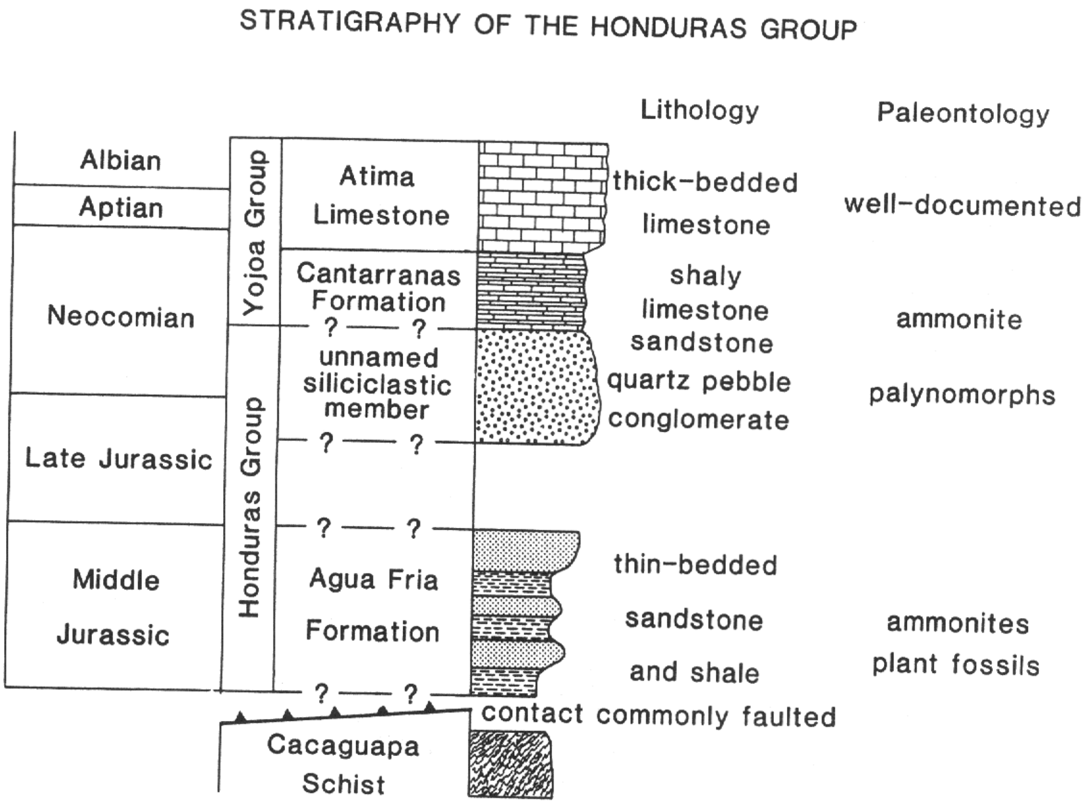

Figure 2. Clastic rocks which crop out beneath the Atima Formation of Mills et al. (1967) were defined as the Honduras Group by Ritchie and Finch (1985). The group consists of two major units, the Agua Fría Formation and the unnamed siliciclastic member. Geologic mapping has not established whether or not the two units occur at the same location. However, the Agua Fría Formation is well-dated (Ritchie and Finch, 1985), and the unnamed siliciclastic member crops out stratigraphically beneath the Atima Formation in numerous locations. The unnamed siliciclastic member is likely Early Cretaceous based on palynomorphs from a few locations, but it has not been well-dated throughout the Chortís block.

Structure

The Cacaguapa Schist experienced several phases of deformation. Its structure has not yet been studied on a regional scale, but local studies have been done in a few widely separated areas. Isoclinal folding has been documented by Fakundiny (1970), Horne et al. (1976) and Simonson (1977). In the Sierra de Omoa, Horne et al. (1976) documented three phases of folding and formation of axial planar foliation and/or cleavage. First generation foliations in the El Porvenir region make a well defined girdle on stereonets indicating folding about a northwest-plunging axis (Simonson, 1977). A second generation foliation is present in the El Porvenir region (Simonson, 1977) which demonstrates that at least two periods of deformation have occurred.

Age

The age of the Chortis basement has not been definitively determined. A limited number of Rb-Sr dates have been determined for the basement rocks. Horne et al. (1976) dated the Quebrada Seca metaigneous pluton by Rb-Sr whole rock dating. Using their data and the new IUGS decay constant ($1.42 \times 10^{-11} yr^{-1}$), L.E. Long (pers. comm., 1990) calculated a date of 300 ± 6 Ma (2σ error) for this rock. It is not clear whether this is a protolith or metamorphic age. However, it clearly demonstrates at least Paleozoic metamorphism occurred on the Chortís block, and that the block is pre-Mesozoic.

Horne et al. (1976) published dates which should not be taken literally because they did not

STRATIGRAPHY OF YOJOA AND VALLE DE ANGELES GROUPS

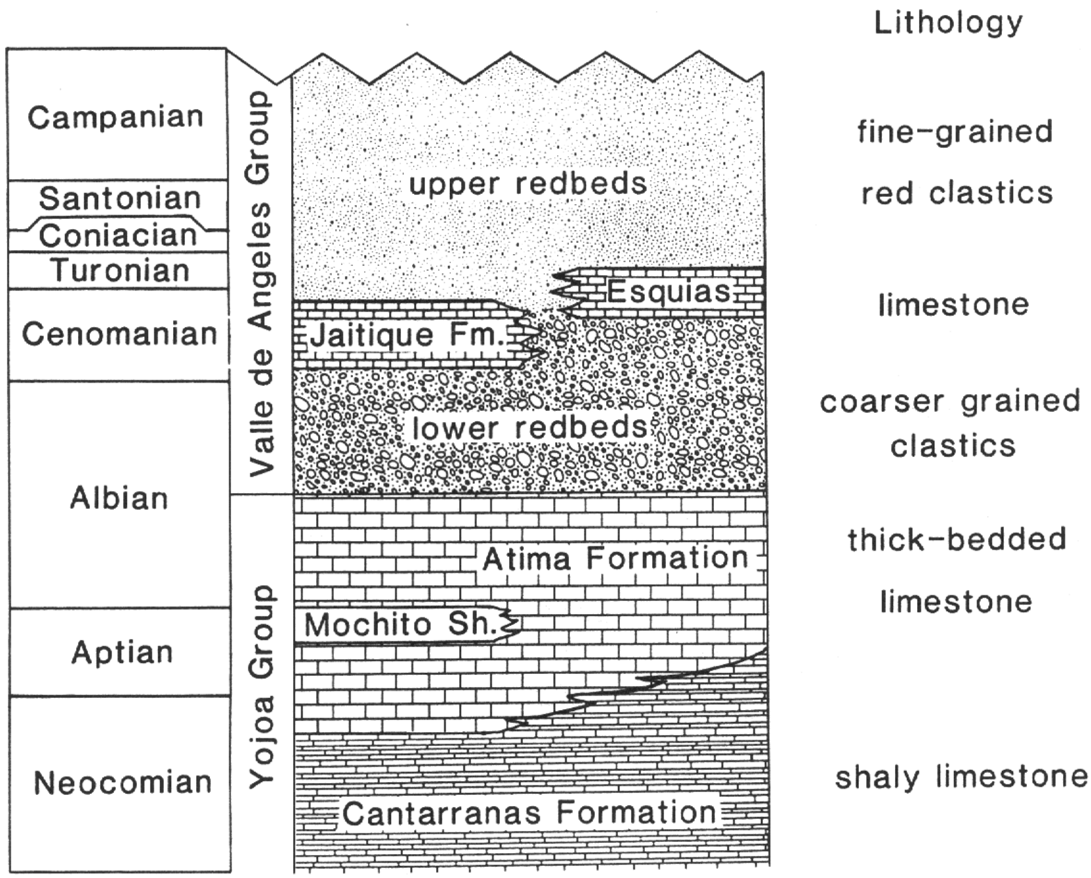

Figure 3) The stratigraphy of Central Honduras is well-known from geologic mapping. Based on this mapping, Finch (1981) revised the stratigraphy of Mills et al., (1967) to incorporate the Cenomanian Jaitique Formation, a limestone unit. This stratigraphy is shown here. The three limestone units have been well-dated with fossils whereas the redbeds have been dated by their stratigraphic position relative to the limestone. A limited amount of palynological data combined with paleomagnetic interpretation suggest that the Valle de Angeles Group does not extend beyond the Campanian (Gose and Finch, 1987).

intend for these dates to be considered precise values. These are either "errorchrons", which assume an initial ratio of $^{87}Sr/^{86}Sr$, or weakly constrained isochrons. The Banaderos metapluton is one that they dated, but the isochron is very poor with large errors. Their date on the Banaderos metapluton is 760 ± 260 Ma (not recalculated because of its large error). The Rb-Sr systematics of the Banaderos pluton may have been disturbed by the intrusion of younger, non-metamorphic quartz monzonite. The errorchrons and the weakly constrained isochrons suggest Paleozoic or Precambrian ages, but do not give tight constraints on the age. Horne et al. (1976) explain the limitations of their isotopic work. Those who cite these data should recognize these problems.

MESOZOIC RECORD

The Mesozoic geology of the Chortís block is dominated by a sequence of clastic sedimentary rocks interlayered with widespread limestone formations (Figs. 2, 3). Volcanic rocks form a relatively minor component of the stratigraphy. Some plutonic rocks have been mapped and dated; with few exceptions these are small bodies. The lack of widespread igneous rocks demonstrates that no long-lasting or pervasive volcanic arc existed on the Chortis block during the Mesozoic.

The Mesozoic stratigraphy has been described by Mills et al. (1967) and Finch (1981). It consists of Middle Jurassic and Early Cretaceous clastic rocks which are overlain by Aptian-Albian limestone. Recent workers have redefined the stratigraphy below the limestone (e.g., Ritchie and Finch, 1985). These clastic rocks are now called the Honduras Group. Two separate units have been mapped, the Agua Fría Formation and the unnamed siliciclastic member (Fig. 2). The Agua Fría Formation consists of gray shale, sandstone and conglomerate. The sandstones are composed of basement detritus. Ammonites and plant fossil demonstrate that the age is Middle Jurassic (Ritchie and Finch, 1985) although its stratigraphic relationship with other rock formations has not been well established. The unnamed siliciclastic member commonly crops out above the Cacaguapa Schist and beneath the Aptian-Albian limestone. Quartz-pebble conglomerate is a dominant lithology. Quartz veins within the basement form the source for these conglomerates. Sandstones are also composed entirely of basement detritus. Palynomorphs from this formation are Early Cretaceous (Gose and Finch, 1987).

The Atima Formation of Mills et al. (1967) is a widespread, well-dated limestone unit. Either the Atima Formation or metamorphic basement crop out beneath the Tertiary volcanics throughout the region of Guatemala south of the Motagua fault (Case and Holcombe, 1980). The Atima Formation crops out extensively throughout Honduras (Mills et al., 1967), and especially Central Honduras (Finch, 1981). It also crops out in northwestern El Salvador (Weber, 1979) and southeastern Guatemala (Burkart et al., 1973). The age range of the Atima Formation is mostly from the Aptian to the middle Albian. It is dominantly a shallow water, reefal limestone. Because it is a readily identifiable unit, Mills et al. (1967) called it the fundamental stratigraphic datum of Honduras. In central Honduras, the limestone is conformably overlain by the Valle de Angeles Group (Fig. 3), which consists of conglomerate, sandstone, shale, and limestone. The Valle de Angeles group is divided into upper and lower redbeds separated by limestone formations (Fig. 3). The redbeds crop out throughout a wide region as does the Atima Formation. Two Cenomanian-Turonian limestones occur within the Valle de Angeles group in Central Honduras (Finch, 1981; Fig. 3). Another Cenomanian limestone crops out in El Salvador (Weber, 1979). The upper age limit for the Valle de Angeles Group has not been definitively established, but palynological and paleomagnetic results suggest that the youngest deposits are Campanian (Gose and Finch, 1987).

The volcanic content within this stratigraphy is remarkably small. The volcanogenic component of the conglomerates and sandstones of either the Honduras or Valle de Angeles Groups is minor. Basement detritus is much more dominant. Interlayered volcanics occur within the stratigraphy, but they are commonly thin (1 m to 10 m). Mills et al. (1967) report volcanic rocks above the Middle Jurassic rocks in the Río Wampú region in eastern Honduras (Fig. 1). During the course of my mapping, I have found that similar rocks occur in other locations along the east side of the Guayape fault (Fig. 1). However, these rocks are limited in age extent. Simonson (1977) reported several hundred meters of volcanics above the Atima Formation near El Porvenir. These are very limited in map extent, cropping out in only about a 100 km^2 area. I have found several hundred meters of volcanics below the Atima Formation in the Catacamas Valley region. These volcanics are also limited in extent to about 100 km^2. Widespread Mesozoic volcanic rocks do not occur on the Chortís block, and a well-defined volcanic arc did not exist in the Mesozoic in the large region where Mesozoic rocks are exposed. If a volcanic arc was associated with the Chortís block it has subsequently been either buried or tectonically separated from the block (Donnelly, 1989). The hypothesis that the Mesozoic arc has been buried seems unlikely because Mesozoic sedimentary rocks, not Mesozoic volcanic or plutonic rocks, are commonly found beneath the Tertiary volcanic rocks. This record is sharply contrasted to the Cenozoic record in which volcanic and plutonic rocks dominate the geology.

The stratigraphic record shows that the Chortís block was a region of minimal tectonic activity during the Mesozoic. It was not the site of major volcanic arc. Significant deformation would need to be limited to post-Atima time. Deformation synchronous with the deposition of the Valle de Angeles Group has not been documented despite extensive 1:50,000 scale geologic mapping in areas that this unit crops out. The general character of the formation (red sandstones and conglomerates) suggests that it is a syntectonic formation. It could have formed in response to tectonic uplift. However, deformation of both the Atima Formation or the Valle de Angeles Group is relatively minor. The Cretaceous sedimentary rocks are folded and faulted. This deformation did not occur until the collision between the Chortís and the Maya blocks in the latest Cretaceous and the Paleocene (Rosenfeld, 1981; Sutter, 1979).

CONCLUSIONS

The available data demonstrate that the Chortís block is a terrane consisting of continental-type crust. Seismic velocities clearly confirm that the entire crust is continental. The geology of the Chortís block is very different than that of Panama and Costa Rica (Case et al., 1984). The age of the basement rocks has not been definitively established, but it is certainly pre-Mesozoic and is probably Paleozoic. The Chortís block is certainly allochthonous relative to North America. Its Mesozoic history was dominated by deposition of sedimentary rocks without significant volcanogenic component. The most widespread marine formation is the Atima Limestone of Aptian-Albian age. Most of the formation was deposited on a shallow shelf, not deep water. Although the basement rocks are highly deformed, folding and faulting of the Atima Limestone is not complex in most locations. Mapped intrusions of Mesozoic age are relatively small. Future work on the origin and tectonic history of the Chortís block needs to be done to make Caribbean reconstructions more viable.

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REFERENCES

Burkart, B., Clemons, R.E., and Crane, D.C., Mesozoic and Cenozoic stratigraphy of southeastern Guatemala, Am. Assoc. Pet. Geol. Bull., 57, 63-73, 1973.

Carpenter, R.H., Geology and ore deposits of the Rosario Mining District and the San Juancito Mountains, Honduras, Central America, Bull. Geol. Soc. Am., 65, 23-38, 1954.

Case, J.E., and Holcombe, T.L., Geologic-Tectonic Map of the Caribbean Region, U.S. Geol. Surv. Misc. Field Inv., Map I-1100, scale 1:2,500,000, 1980.

Case, J.E., Holcombe, T.L., and Martin, R.G., Map of geologic provinces in the Caribbean region *in* Bonini, W.E., Hargraves, R.B., and Shagam, R. (eds.), The Caribbean-South America Plate Boundary and Regional Tectonics, Geol. Soc. Am. Mem., 162, 1-30, 1984.

Castro Escamilla, R.R., Un modelo de la corteza terrestre para el sur de México Mediante el uso de sismos profundos [Ing. Tesis], Universidad Nacional Autónoma de México, 74 p., 1980.

Dengo, G., Problems of tectonic relations between Central America and the Caribbean, Trans. Gulf Coast Assoc. Geol. Soc., 19, 311-320, 1969.

Dengo, G., and Bohnenberger, O., Structural development of northern Central America *in* McBirney, A.R. (ed.), Tectonic Relations of Northern Central America and the Western Caribbean -- The Bonacca Expedition, Am. Assoc. Pet. Geol. Mem., 11, 203-220, 1969.

Donnelly, T.W., Geologic history of the Caribbean and Central America *in* Bally, A.W., and Palmer, A.R. (eds.), The Geology of North America--An overview, Geological Society of America, The Geology of North America, v. A, 299-321, 1989.

Fakundiny, R.H., Geology of the El Rosario quadrangle, Honduras, Central America [Ph.D. Diss.], University of Texas, Austin, 234 p., 1970.

Fakundiny, R.H., Mapa Geológico de Honduras, El Rosario sheet, Instituto Geográfico Nacional, scale 1:50,000, 1971.

Finch, R.C., Mesozoic Stratigraphy of Central Honduras, Am. Assoc. Pet. Geol. Bull., 65, 1320-1333, 1981.

Gomberg, D.N., Banks, P.D., McBirney, A.R., Guatemala: Preliminary zircon ages from the Central Cordillera, Science, 162, 121-122, 1968.

Gose, W.A., Paleomagnetic results from Honduras and their bearing on Caribbean tectonics, Tectonics, 4, 1985.

Gose, W.A., and Finch, R.C., Magnetostratigraphic studies of Cretaceous rocks in Central America, Actas Fac. Ciencias Tierra U.A.N.L. Linares, 2, 233-241, 1987.

Horne, G.S., Clark, G.S., and Pushkar, P., Pre-Cretaceous rocks of northwestern Honduras: basement terrain in Sierra de Omoa, Am. Assoc. Pet. Geol. Bull., 60, 566-583, 1976.

Kim, J.J., Matumoto, T., and Latham, G.V., A crustal section of northern Central America as inferred from wide-angle reflections from shallow earthquakes, Bull. Seismol. Soc. Am., 72, 925-940, 1982.

Kozuch, M.J., Geology of the San Francisco de Becerra quadrangle, Honduras, Central America, Open-file report, Instituto Geográfico Nacional, Tegucigalpa, Honduras, 55 p., 1989.

Matumoto, T., Ohtake, M., Latham, G., and Umana, J., Crustal structure in southern Central America, Bull. Seismol. Soc. Am., 67, 121-134, 1977.

McBirney, A.R., Geology of a part of the central Guatemalan Cordillera, Univ. Calif. Pub. Geol. Sci., 38, 177-242, 1963.

McBirney, A.R., and Bass, M.N., Geology of the Bay Islands, Gulf of Honduras *in* McBirney, A.R. (ed.), Tectonic Relation of Northern Central America and the Western Caribbean--The Bonacca Expedition, Am. Assoc. Pet. Geol. Mem., 11, 229-243, 1969.

Mills, R.A., Hugh, K.E., Feray, D.E., and Swolfs, H.C., Mesozoic stratigraphy of Honduras, Am. Assoc. Pet. Geol. Bull., 51, 1711-1786, 1967.

Ritchie, A.W., and Finch, R.C., Widespread Jurassic strata on the Chortis block of the Caribbean plate, Geol. Soc. Am. Abstr. Progs., 17, 700-701, 1985.

Rodbell, A.A., Geology of the Guaimaca quadrangle, Honduras, Central America, Open-File Report, Instituto Geográfico Nacional, Tegucigalpa, Honduras, 27 p., 1986.

Rosenfeld, J.H., Geology of the Western Sierra de Santa Cruz Guatemala, Central America: An ophiolite sequence [Ph.D. Diss.], State University of New York, Binghamton, 313 p., 1981.

Simonson, B.M., Geology of the El Porvenir quadrangle, Honduras, Central America, Open-file report, Instituto Geográfico Nacional, Tegucigalpa, Honduras, 84 p., 1977.

Simonson, B.M., Mapa Geológico de Honduras, El Porvenir sheet, Instituto Geográfico Nacional, Tegucigalpa, scale 1:50,000, 1981.

Sutter, J.F., Late Cretaceous collisional tectonics along the Motagua fault zone, Guatemala, Geol. Soc. Am., Abstr. Progs., 11, 525-526, 1979.

Weber, H.-S., On the lithology and stratigraphy of the "Estratos de Metapán" in the Republic of El Salvador, Central America, Geol. Jb., B37, 31-54, 1979.
Weyl, R., Geology of Central America, Gebrüder Borntraeger, Berlin, 371 p., 1980.
Zoppis Bracci, L., Estudio preliminar de las mineralizaciones de tungsteno y molibdeno de Macuelizo, Departamento de Nueva Segovia, Bol. Serv. Geol. Nac. Nicaragua, no. 5, 33-52, 1961.